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RUTGERS - THE STATE UNIV NEW BRUNSWICK N J DEPT OF PSYCHOLOGY E KOWLER 11 APR 83 AFOSR-TR-83-0458

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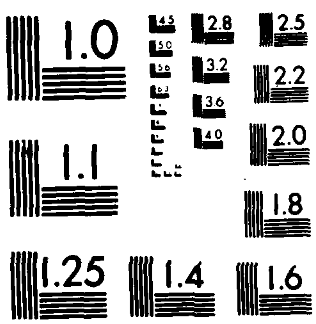

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFOSR-TR- 83-0458	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Eye Movements and Visual Information Processing		5. TYPE OF REPORT & PERIOD COVERED Interim Scientific Rept 01/01/82-31 Dec 82
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Eileen Kowler		8. CONTRACT OR GRANT NUMBER(s) AFOSR - 82 - 0085
9. PERFORMING ORGANIZATION NAME AND ADDRESS Rutgers University - Dept of Psychology New Brunswick, NJ 08903		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61102F 2313/A5
11. CONTROLLING OFFICE NAME AND ADDRESS AFOSR/NL Bolling AFB, DC 20332		12. REPORT DATE April 11, 1983
		13. NUMBER OF PAGES 8
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Eye Movements, Visual Information Processing, Vision

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Eye movements determine the location and velocity of the retinal image. Thus, to understand how we see it is necessary to understand both how eye movements are controlled and how they affect visual information processing. The proposed research is concerned with

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both problems. Specifically:

(1) The effect of expectations on smooth eye movements. The eye moves smoothly in the direction of expected future target motion. Experiments will determine: (1) how expectations and guesses about the direction of future motion are formulated and (2) the relative contributions of expectations and retinal image motion to smooth eye movements.

(2) The effect of saccades and saccade-like stimulus perturbations on visual information processing. Saccades continually displace the retinal image, yet we see the world as a single coherent picture. Experiments will find out whether the visual system selectively tolerates rapid lateral displacements, or whether the decision to move the eye is required.

(3) Programming sequences of saccades. Experiments will show whether sequences of saccades can be pre-programmed, and whether use of such sequences improvesperformance of visual tasks.

AFOSR Grant number 82-0085
Interim Scientific Report
April, 1983

EYE MOVEMENTS AND VISUAL INFORMATION PROCESSING

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ABSTRACT

Eye movements determine the location and velocity of the retinal image. Thus, to understand how we see it is necessary to understand both how eye movements are controlled and how they affect visual information processing. The proposed research is concerned with both problems. Specifically:

(1) <u>The effect of expectations on smooth eye movements</u>. The eye moves smoothly in the direction of expected future target motion. Experiments will determine: (1) how expectations and guesses about the direction of future motion are formulated and (2) the relative contributions of expectations and retinal image motion to smooth eye movements.

(2) <u>The effect of saccades and saccade-like stimulus perturbations on visual information processing</u>. Saccades continually displace the retinal image, yet we see the world as a single coherent picture. Experiments will find out whether the visual system selectively tolerates rapid lateral displacements, or whether the decision to move the eye is required.

(3) <u>Programming sequences of saccades</u>. Experiments will show whether sequences of saccades can be pre-programmed, and whether use of such sequences improvesperformance of visual tasks.

PROGRESS REPORT (January, 1, 1982 to December 31, 1982)

1. Development of laboratory facilities. The LSI 11/23 computer system is fully operational. Hardware and software interfacing between the computer and the peripheral devices (analog-to-digital converters, digital-to-analog converters, parallel line board, and clock) is completed. Software for control of experiments is near completion. A comprehensive software library for analysis of eye movement and psychophysical data has been developed and is in active use.

I visited SRI International twice with an engineer (M. Pavel) to test the Generation IV Dual Purkinje Image Eyetracker. Tests of noise level, bandwidth, linearity and ease of operation were carried out. Necessary modifications were made and the tracker was delivered in May, 1982. Aligning and mounting of the tracker, biteboard holder, and stimulus optical equipment (optical benches, display monitors, collimating lenses) was completed. Pavel will replicate and extend his test of noise, linearity and bandwidth and prepare a paper describing the results.

2. Submitted ms:

Kowler, E. and Sperling, G. Abrupt onsets do not aid visual search. ~~Submitted to~~ Perception and Psychophysics, in press.

Kowler, E., Martins, A. and Pavel, M. The effect of expectations on slow oculomotor control: Anticipatory smooth eye movements depend on prior target motions. Submitted to Vision Research, reviewed, and undergoing revision.

3. Research in progress: Programming sequences of saccades.

A common assumption in studies of tasks requiring use of saccades is that saccades are planned one at a time. Experiments are underway to determine whether subjects can preprogram sequences of saccades. The experiment already begun is modeled after Sternberg et al.'s (1978) study of preprogramming of sequences of motor responses used in typing and speech. Sternberg et al. (1978) found that characteristics of individual responses (latency of the first response and time between responses) are a function of properties of the sequence as a whole. (e.g., sequence length). Their finding suggests that observers prepare all the motor commands for the sequence before response execution begins.

I found similar results for saccades. Two subects were presented with either 1, 3 or 5 stationary point targets which occupied the vertices of a pentagon. Separation of adjacent targets was 217 min arc. Subjects were instructed to look from point to point as quickly as possible. The mean latency of the first saccade increased with the number of targets presented (see Figure 1). This result suggests that motor commmands for the entire sequence of saccades are preprogrammed before the first saccade occurs.

Additional results include:

1. The observed effect of the number of targets in the sequence on the latency of the first saccade requires practice. The inexperienced subject (see dotted line, Figure 2) showed an effect of the number of targets only during the second halves of 10-trial blocks spent tracking the same stimulus.

2. Saccade size (Figure 3) and latency (Figure 4) vary as a function of the stimulus location from which saccadic tracking began. Some locations produced short latencies and short saccades; others produced long latencies and long saccades.

3. Latencies of saccades tended to increase as the subjects made saccades through the sequence (Figure 5). Sacccade sizes tended to decrease through the sequence (Figure 6).

4. Extensive practice (60 trials) making saccades to the 5-target stimuli, always begnning at the same start location, did not affect the latencies (Figure 7) but did affect saccade sizes (Figure 8).

These results confirm the expectation that characteristics of saccades (i.e,, size and latency) depend on characterisitics of the entire sequence, for example, sequence length or serial position in the sequence. Some individual differences and effects of practice were observed. This suggests that learned, preprogrammed patterns of saccades are used to inspect visual scenes. The proposed experiments will explore how the patterns are learned and study the consequences of the use of saccadic patterns for vision.

Figure Legends

Figure 1. Mean latency of the first saccade in the sequence as a function of the number of targets to be scanned for experienced subject RS (solid line) and for inexperienced subject DF (dotted line).

Figure 2. Top: Mean latency of the first saccade in the sequence as a function of the number of targets to be scanned for subjects RS (solid line) and DF (dotted line) averaged over trials in the first halves of 10-trial blocks. Bottom: Same, except latencies are averaged over the trials in the second halves of 10-trial blocks.

Figure 3. Mean size of the first saccade in the 5-target sequences as a function of start location for subjects RS (solid line) and DF (dotted line). The outline pentagon shows the start locations.

Figure 4. Same as Figure 3, except mean latency of the first saccade is shown.

Figure 5. Mean latency of all saccades in the 5-target sequences as a function of serial position in the sequences for subjects RS (solid line) and DF (dotted line).

Figure 6. Same as Figure 5, except mean size is shown.

Figure 7. Mean time between saccades in the 5-target sequence with start location 4 for subject RS before (solid line) and after (dashed line) 60 trials of practice with this stimulus.

Figure 8. Same as Figure 7, except mean size is shown. The arrow points to the actual separation between adjacent targets.

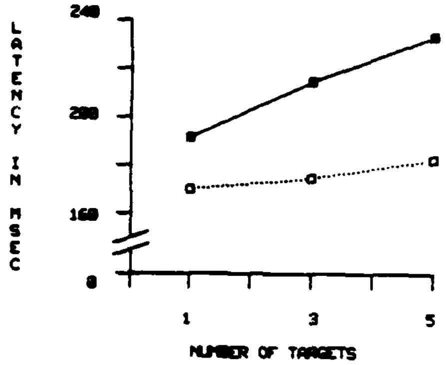

Fig. 1

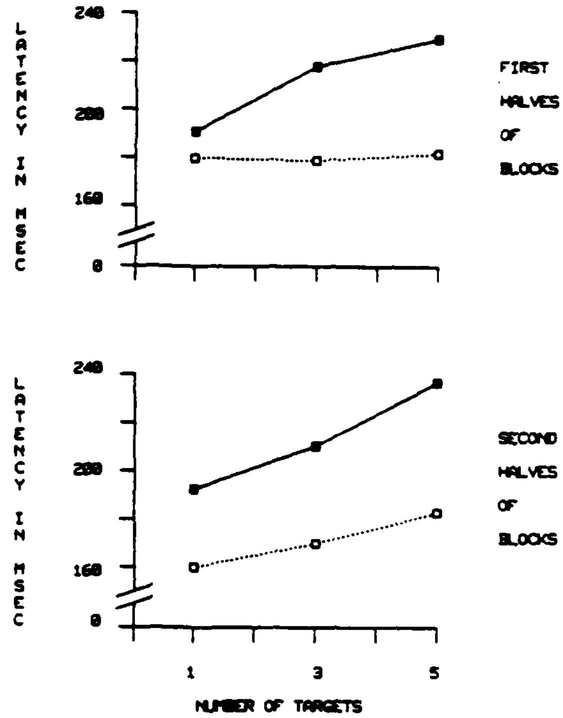

Fig. 2

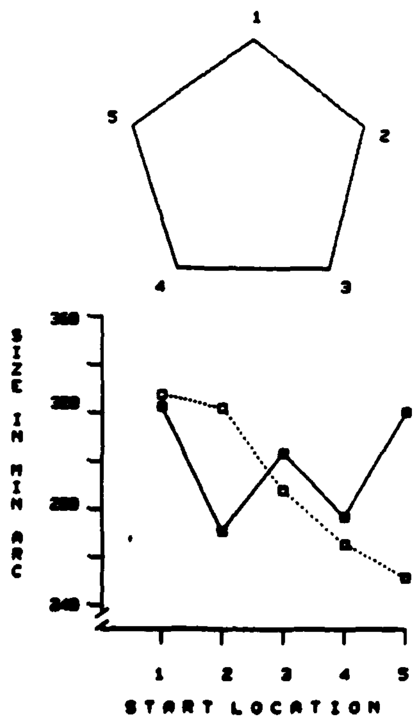

Fig. 3

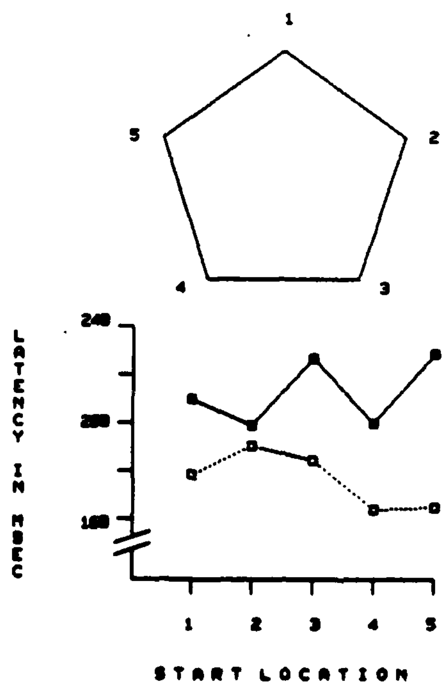

Fig. 4

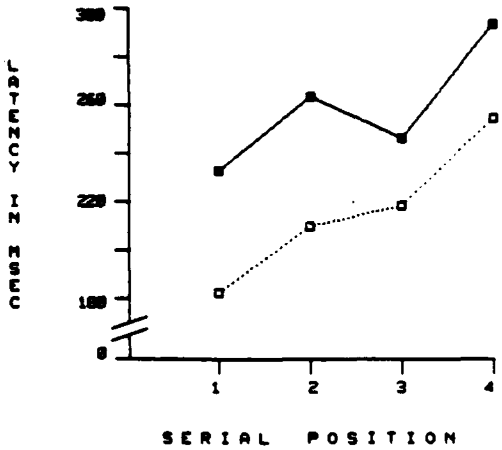

Fig. 5

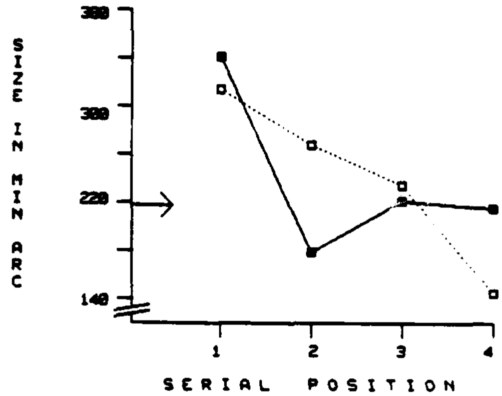

Fig. 6

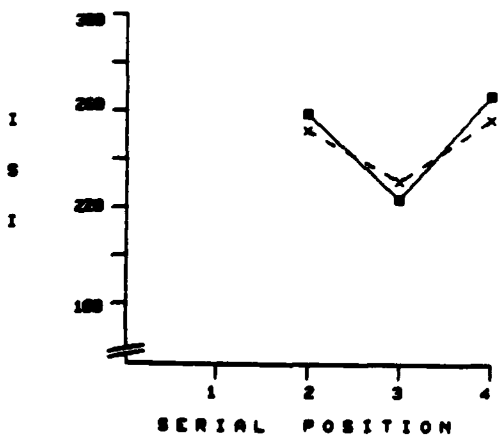

Fig. 7

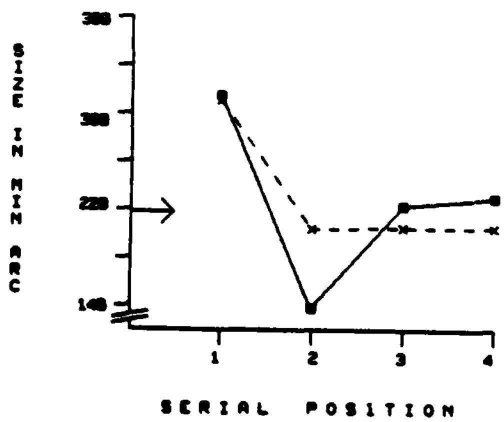

Fig. 8

Progress Report (1/1/83 to 4/11/83)

1. Tests of the SRI Generation IV Dual Purkinje Image Tracker are in progress. Necessary adjustments to ensure optimal bandwidth are being carried out.

2. An experiment on reading of transformed text is in progress. This experiment will determine whether subjects (1) pre-program sequences of saccades during reading as they do when looking at an array of stationary points (see above) and (2) whether such pre-programming also occurs when subjects read text that has been rotated 180 deg around the x, y or z axis.

3. Analyses are in progress on an experiment on smooth pursuit of small amplitude sinusoidal target motions (in collaboration with A. Martins). Results so far suggest that smooth pursuit velocity is equal to some specified fraction of target velocity (where the fraction depends on the frequency of the sinuosidal motion) plus a constant velocity which is equal to the average velocity of the eye when targets are stationary.

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